Demarcation of Natural Resources in Nuwara Eliya Estate at Labukale

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Abstract

Digital mapping of estate sector demarcating natural and other resources is a new mission in Sri Lanka. A study was conducted to demarcate water resources, natural forest and the soil in Nuwara Eliya Estate at Labukale using GIS techniques.Required information was collected by field visits and from the Estate offices. Global Positioning System (GPS) was used to demarcate all the locations of tea lands, natural forests, water resources and other cultivable lands. In order to identify the soil physical conditions, 98 soil samples were taken from 49 locations of the estate including different land covers from surface and 20 cm depth soil. Soil samples were analyzed for determination of the soil EC and soil pH. ArcView GIS 3.2a software was used for the spatial analysis and mapping. Results of the study revealed that the extent of the tea estate is 246.7 ha. In the estate, 69% of the total extent contains tea fields while vegetable is growing on 18% and 13% belong to a natural forest. Surface soil pH of the estate ranges from 5.7-7.9 and surface soil EC ranges from 7.4 – 49.4 µs. The highest pH values and EC values observed at the low elevation of the estate at the proximity of the river. Surface soil pH and 20 cm depth soil pH showed significant difference. There were negative relationships between elevation and the soil pH as well as between soil EC and the elevation. Surface soil pH values are almost higher than the 20 cm depth soil pH values. Higher surface soil pH values can be observed at the vegetable lands. 20 cm depth soil EC values were higher than the surface soil EC. Higher EC values were observed at the tea fields. Average yield did not depend on the pH and EC values of the soil. Elevation pattern of the estate varies from 1680 m to 2110 m. The yield of tea field did not depend on the elevation of the tea fields.

Keywords: Nuwara Eliya, natural resources, GIS, demarcation

Introduction

Sri Lanka is one of the smallest, but biologically diverse countries in Asia. Sri Lanka has been identified by the environment activist group Conservation International (CI) as one of 25 biodiversity hot spots in the world. These hot spots can be benefitted by preservation efforts (Amarasekera, 2012). Sri Lanka is fortunate to be blessed with one of the highest per capita fresh water resources in the world and each year enough rainfall is received to fill our lakes, reservoirs, streams and rivers. This provides an outstanding competitive advantage to our country (Strong Fundamentals Assure Stability, 2011). It is difficult to perform a plantation without any impact on the environment. It is important to identify biologically important areas for the proper preservation of those areas in sustainable environment management. In this context, identification of the real static boundaries is very important. This can be done by using the Geographical Information Systems.

The main objectives of this research were (1) to demarcate natural resources including water bodies, forests and soil of the estate (2) to identify the changes of soil parameters in different cultivation lands and forest (3) to identify the relationships among soil parameters, yield and the elevation.

Materials and Methods

Nuwara Eliya Estate situated in Nuwara Eliya divisional secretariats in Nuwara Eliya District of central province of Sri Lanka. It covers total area of about 246.058 ha between latitudes 7.012348 and 7.009579 North and longitude 80.722167 & 80.748389 East. The main data source was Google image with 30,000 × 30,000 pixels resolution BMP format. The image was registered with survey maps of survey department of Sri Lanka. Field attributes data and yield data were collected by field visits and estate office.

The basic spatial layers, such as administrative boundaries, roads and buildings etc. were developed by using ESRI's ArcView (ver. 3.2a). In addition, the digital elevation model was derived from the survey maps of survey department of Sri Lanka. The data collection in the field was aided by GPS in order to locate the water resources points on the image. Attribute information on vegetation, geomorphologic, soil and topographic parameters were also collected. Soil data were collected from 49 locations representing the each and every field areas. Soil samples were taken from surface soil and 20 cm depth layers. Both surface soils and 20 cm depth soils were collected separately.

Soil analysis was done to determination of soil pH and soil EC. Soil variation maps were generated by using IDW interpolation method by using ArcView 3.2. Land usage maps were built by using data gathered by field surveys. Relationships among land usage, elevation, soil properties and average yield were determined by overlaying those maps on each other.

Results and Discussion

The different land usage patterns and categories of the estate are shown by Figure 1 and 2.Total extent of the estate is 246.7 ha. It is evident the highest land area was covered by tea cultivation and lowest was covered by the natural forest.

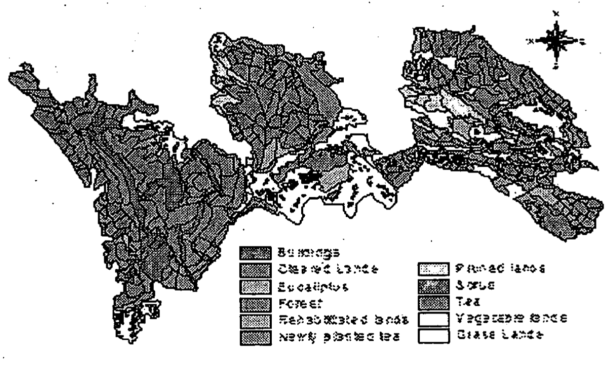

Figure 1. Land usage of the estate

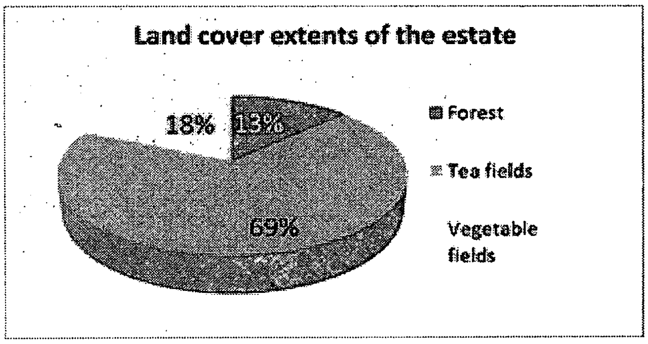

Figure 2. Proportion of land usage categories

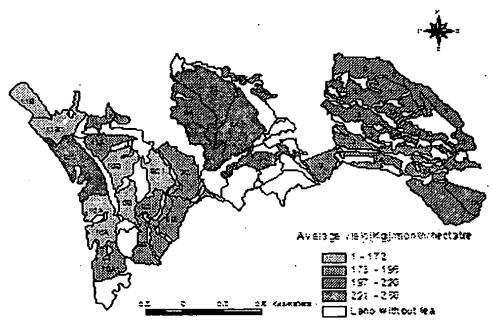

Figure 3. Average cycle yields of the fields per hectare per month

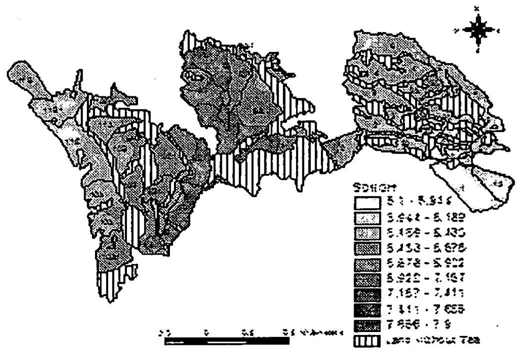

Figure 4. Distribution of surface soil pH of the estate

The yield differences per hectare per month is shown by Figure 3. The results did not show significant relationships among yield and soil pH or yield and soil EC or yield and the elevation. Surface soil pH ranges from 5.7 to 7.9 throughout the estate (Figure 4). It is in the optimum range of tea and vegetable cultivations and for forests.

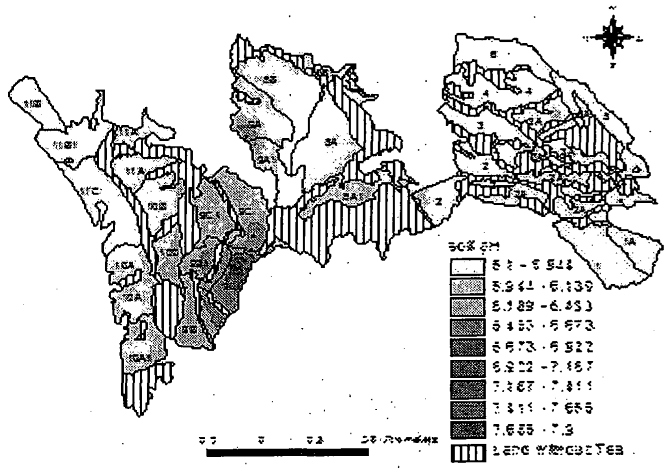

Figure 5. Distribution of 20cm deep soil pH

pH of 20 cm deep soil ranges from 5.1 to 7.3 as shown in Fig 4. Soil pH increases with the slope towards the river. Fig 6. shows the distribution of surface EC of the estate. EC values increased towards the river with the slope.

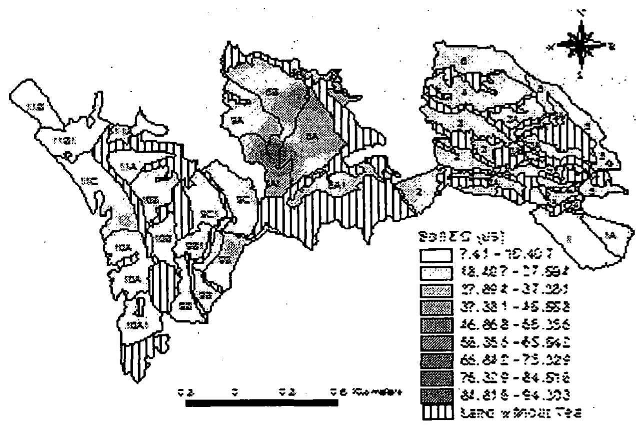

Figure 7. Distribution of 20cm deep soil EC

EC values of 20 cm depth soil were varied from 7.4 to 49.4 µs. The highest EC values were observed at the proximity of the streams.

Fig 8. shows the soil pH variation among different land usage covers. There was no significant difference of pH values among land usage. However, top soil shows higher pH values than pH values of 20 cm depth soil.

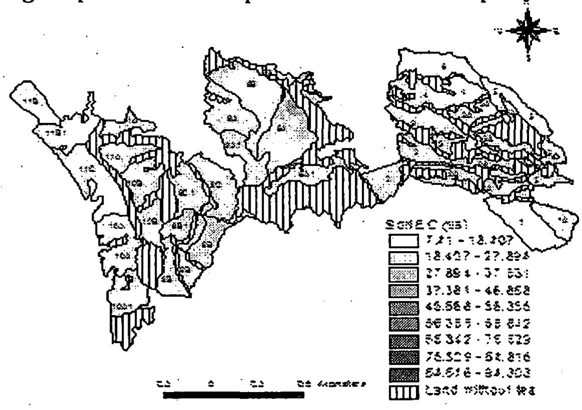

Figure 6. Distribution of surface soil deep soil EC of the estate

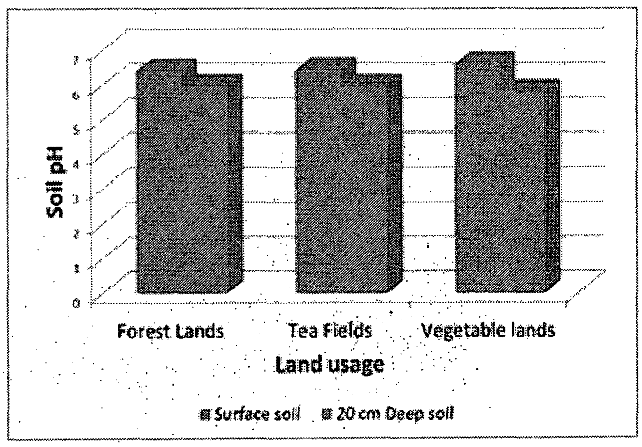

Figure 8. Soil pH variation with the land usage

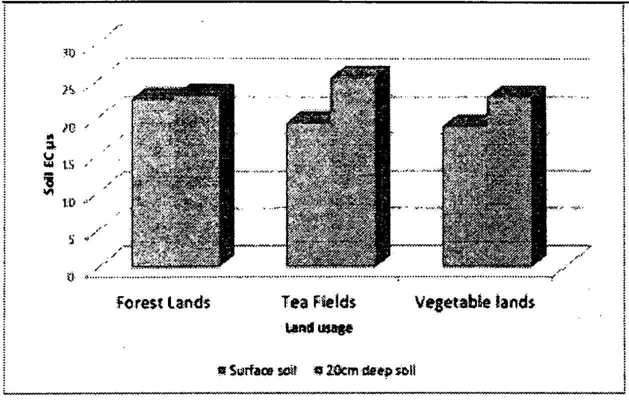

Figure 9. Soil EC variation with the land usage

Fig 9. shows variation of soil EC among different land use covers. It is revealed that higher EC values were found in 20 cm depth soil samples in tea lands.

Conclusions

Natural resources of the estate including water resources, forest and the soil condition were demarcated. Total extent of the estate was 246.7 ha. 69% of total land extent contains tea fields while 13% and 18% of total land extent contain forest and vegetable lands, respectively. There was a significant difference between surface soil and 20 cm depth soil pH of the estate. There was a positive correlation between soil pH and soil EC. Surface soil pH values were almost higher than the 20 cm depth soil pH values. Higher surface soil pH values were observed at the vegetable lands. 20 cm depth soil EC values were higher than the surface soil EC. Higher EC values were observed at the tea fields. There are negative relationships between elevation and the soil pH values as well as between elevation and soil EC.

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Spatial Distribution and Dynamics of Salinity and Associated Water Qualities in Integrated Water Sources in Negombo-Muthurajawela Area

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Abstract

The study was conducted in Negombo-Muthurajawela area during September-December 2012, to identify water dynamics and spatial water quality variation in interconnected surface water bodies in the areas of Negombo lagoon, Hamilton canal, Dutch canal, Ja-Ela and Dandugam-Oya. Locations of sample sites were demarcated using the Global Positioning System (GPS). pH, electrical conductivity (EC), salinity, chloride, sulphate, alkalinity, and turbidity of water were recorded from surface, middle and bottom levels of the sources, in monthly intervals. Piper chart hydrological analysis method was performed to classify the quality of water. EC levels of the water bodies varied from > 40000 µS in dry periods and <10000 µS during wet periods. Lagoon water was slightly alkaline throughout the study period (average 7.58). EC, pH and salinity levels decreased from lagoon outlet to its inlet. Average salinity levels of the lagoon during the dry period and wet period were 27.39 ppt and 1.41 ppt, respectively. EC, pH and salinity levels increased towards the lagoon in Dutch canal, Ja-Ela and Dandugam-Oya. However, EC, pH and salinity levels decreased from Kelani estuary to southern lagoon inlet in the lower part of the Hamilton canal. Lagoon water was Non Dominant Cation type bicarbonate water and rest of the water was mostly fresh and it can be classified as Magnesium type.

Key words: Negombo lagoon, salinity and alkalinity, water quality

Introduction

The Negombo lagoon (79° 48'937"- 79° 53'678"E and 6° 58'171" and 7° 16'246") in the west coast of Sri Lanka, is 6232 ha in extent. It mainly receives water from Attanagalu-Oya (Ja-Ela and Dandugam-Oya) (Silva, 1996). In addition to that, Hamilton canal and Dutch canal, which are running parallel to the west coast from the north to the south along the Muthurajawela marsh connecting watercourse of the Kelani estuary and the Negombo lagoon. The construction of Hamilton canal along the Western boundary of Muthurajawela was done during the British period (Dissanayake, 1993).

Negombo lagoon (3164 ha) is connected by a single narrow opening with the sea. The Muthurajawela marsh (3068 ha) extends southward from the lagoon. According to the "Conservation management plan: Muthurajawela marsh and Negombo lagoon, (Central Environmental Authority, 1994)" the entire wetland is separated from the sea by a sand barrier situated on beach rock formed during relative sea level changes at the past.

Study area has hydrological interconnection as singular body. There was an interconnection between fresh, brackish and saline water, which is affected by various factors. The lagoon and integrated surface water sources are habitat to a rich array of plants and animals that depends on its water quality for their existence. Humans also depend on the lagoon and surface water sources for recreational and commercial activities. At the same time; silts, sediments, nutrients,

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chemicals, oils and metals find their way into the lagoon as the result of anthropogenic activities in the area.

Therefore, measures should be taken to make a meaningful assessment of the water quality of the Negombo lagoon and its interconnected surface water bodies, their relationship and influence to each other and spatial variation of water quality. The main objectives of the present research were to (1) assess water dynamics of integrated surface water bodies in Negombo-Muthurajawela area, (2) identify spatial water quality variation with respect to depth of the water bodies of the area and (3) assess the impact of weather factors on the water quality of water bodies in the area.

Materials and Methodology

The monitoring network of surface water in Negombo-Muthurajawela area had 43 sampling points including 20 points in the lagoon and 23 in streams, keeping 4 km distance apart in canals and 3 km distance apart in the Negombo lagoon in 5 transacts. 20 sampling points at one kilometer distance were selected within a single transect.

Water monitoring was conducted in the first week of each month, during September to December 2012. The locations of water sampling points were recorded using GPS and location map of sample sites were prepared using GIS Map software 9.2. All samples were taken within two days at a unique tidal influence (ebb- neap tide). It helps to avoid the spot errors occurring by tidal waves, rain or other natural and climatic incidents. Samples of canals and rivers contained five sub samples representing both banks and three samples from the center representing surface, middle and bottom water layers.

Portable YSI 63 multipara meter was used for in situ measurements of salinity, EC, pH and temperature parameters. Laboratory test was carried out to test turbidity, colour, chloride, sulphate and alkalinity. GIS software (Arcmap 9.2) was used for the preparation of hydro-geological and hydro-geochemical and bathymetry maps.

Results and Discussion

EC variation in a selected longitudinal section from Kelani estuary to Maha-Oya is demonstrated in Fig. 1. Longitudinal section includes Kelani river inlet, lower part of Hamilton canal (H2, H4, and H5), Negombo lagoon (15D, 10C, 5B) and upper part of the Hamilton canal (H6, H7 and Maha-Oya inlet). EC decreased towards the lagoon in the lower part of Hamilton canal and it increased from lagoon inlet to lagoon outlet due to communication with sea water. EC of water rapidly decreased from lagoon to Maha-Oya in the upper part of the Hamilton canal, due to fresh water intrusion from Maha-Oya. EC increased at the lagoon inlet (H6) with subsequent decreased at the middle region of the upper part of the Hamilton canal, and increased it again at the connecting point to Maha-Oya.

EC increment at Kelani estuary and lagoon inlet of upper part may be due to tidal influence from sea and entrance of brackish water from lagoon. Lowest and highest EC values were observed in November and October, respectively. Average EC values in Hamilton canal were 36936, 1459 and 6818 µS for October, November and December respectively. EC decreased by 25 times in November compare to October, which may be associated with the rainfall. According to Pearson correlation coefficient values, there was a positive correlation of 0.888, 0.994 and 1.000 between salinity and EC for October, November and December, respectively. Lowest salinity levels were observed during November due to high precipitation (567.4 mm) and highest in October due to less rainfall (110.2 mm). Salinity changed from 0.2 to 20.4 ppt along the canal. Salinity decreased from Kelani estuary to lagoon inlet (lower part) and there was an increment of salinity at the upper part inlet and at the Maha-Oya. Highest EC of the lagoon existed in October and lowest in November. Moreover, EC was increased by 10 to 50 times at lagoon outlet compare to lagoon inlet during all the three months. EC varied from 500 to 55000 µS throughout the lagoon body.

pH ranged from 6.76 to 8.15 along the selected longitudinal section. Lowest pH value was observed in November (pH= 6.7). pH of the lagoon was mostly alkaline while Hamilton canal showed slightly acidic conditions. pH was high at lagoon outlet, which gradually decreased towards the inlet during all three months.

Average pH value of the lagoon was 7.58. pH of the lagoon during the three months varied from 6.53 to 8.14. pH had a decrement at November due to heavy

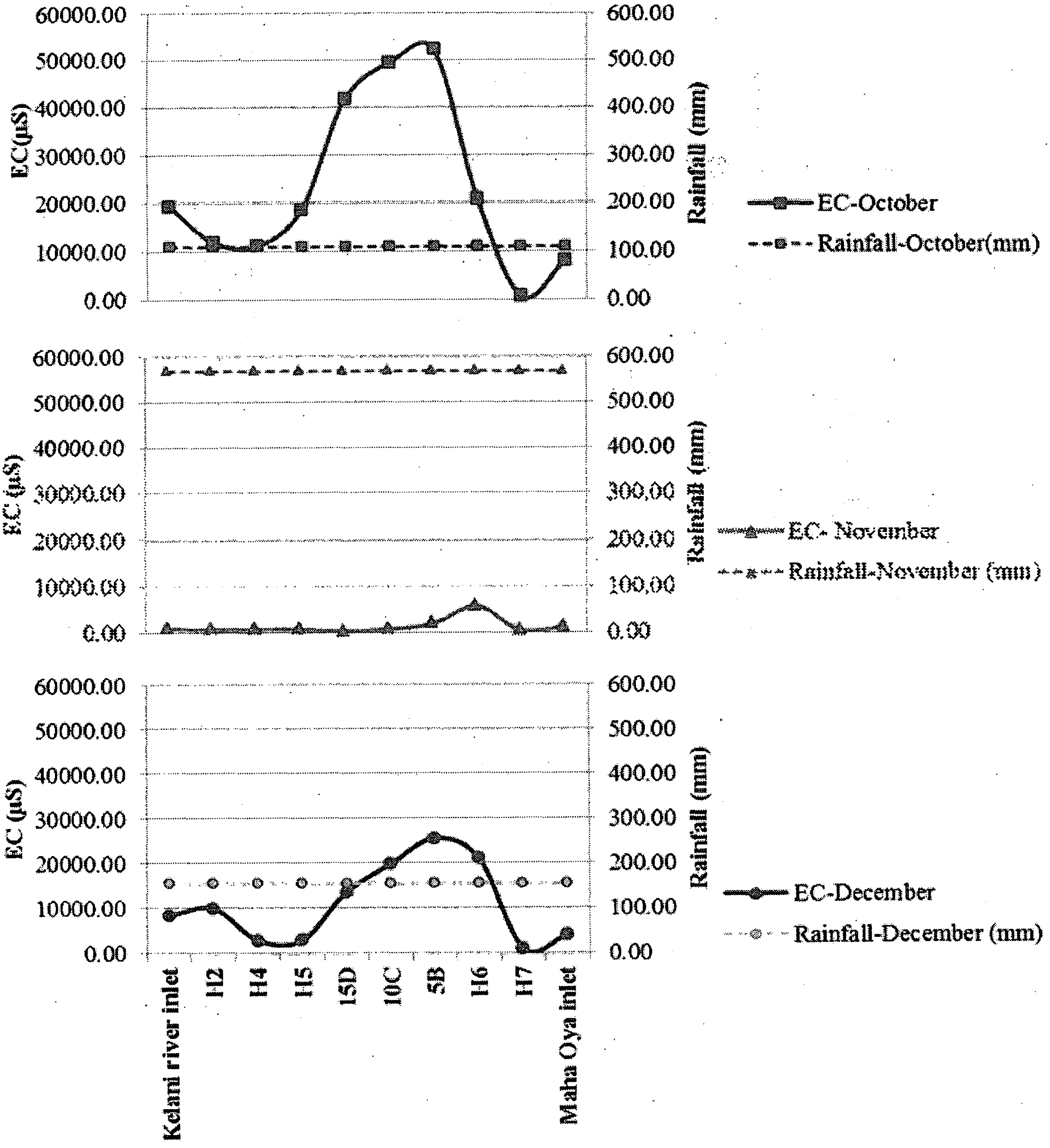

Figure 1: EC variation from Kelani estuary to Maha-Oya

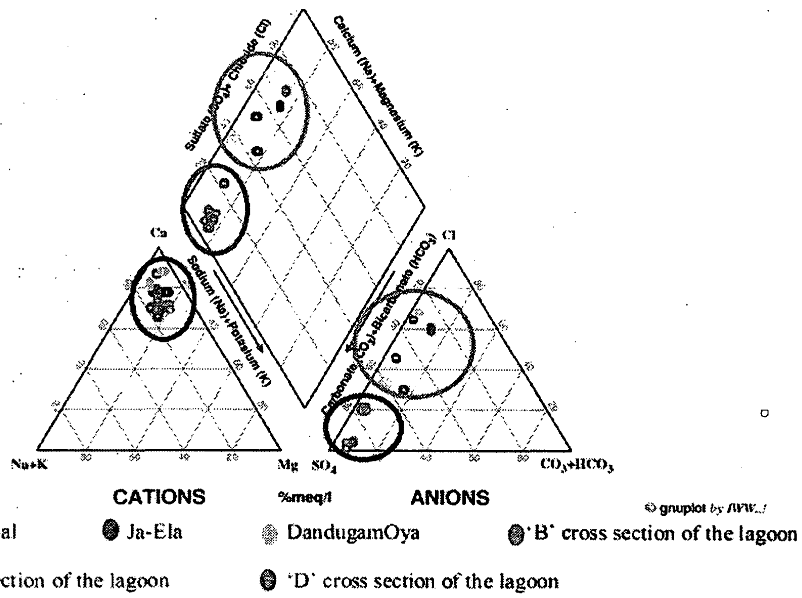

Figure 2: Piper diagram for water classification

rainfall. Slight acidity of the rain water in the study area may be the reason for that.

Piper diagram (Fig. 2) reveals that water in the study area was mostly sodium dominant. But according to the anions it was mostly chloride dominant mix with Sulphate. Lagoon water was mostly consisted with chloride. Surface water in the study area can be classified as Non Dominant Cation type (NDC). Lagoon water was Non Dominant Cation type Bicarbonate water. Rest of the water was mostly fresh and it can be classified as Magnesium Type.

Conclusions

EC levels of the water bodies in Negombo lagoon area varied from > 40000 μS in dry periods to < 10000 μS during wet periods due to dilution effect from rain water. Analogically average salinity levels of the lagoon during dry and wet periods varied from 27.39 ppt to 1.41 ppt, respectively.

Salinity levels in the lagoon were influenced by sea water communication rather than organic activities existed in the lagoon during the dry periods. Lagoon water was lightly alkaline (average pH>7.58) and water in canals and streams were slightly acidic (pH<7). Precipitation was significantly influenced the pH and salinity changes of lagoon and streams.

Water type in the lagoon can be classified as "NDC type Bicarbonate" according to the Piper classification. However, the water in the other water bodies (Dandugamoya, Ja-Ela, and Dutch canal) was mostly fresh and can be classified as a Magnesium type.

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Development of Muffin using *Buthsarana* (*Canna edulis* ker.) Yam Flour and Evaluation of its Quality Parameters

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Abstract

Buthsarana is one of the underutilized tuber crops in Sri Lanka with a high potential to develop value-added food products. A muffin can be defined as a type of quick bread that is baked in small portions. The objectives of the study were to explore the possibility of utilizing Buthsarana flour in preparation of muffin and to evaluate its physicochemical, sensory and microbiological properties. Well-mature, peeled-off Buthsarana yam pieces were dried at 65°C for 6 h and flour was prepared by grinding the yam. Muffins containing 25, 50, 75 and 100% (w/w) Buthsarana flour were prepared and compared with 100% (w/w) wheat flour muffin sample in terms of physicochemical and sensory properties. Sensory properties were determined using a five-point hedonic scale by 30 untrained sensory panelists. Sensory scores were analyzed using Kruskal-Wallis non-parametric one way ANOVA. Muffin containing 100% Buthsarana flour showed significantly higher ($p<0.05$) overall acceptability. Proximate composition of 100% Buthsarana flour muffin included 4.8% proteins, 11.6% fat, 1.9% ash, 4.3 % fiber and 51.8% carbohydrates. Yeast and mould counts increased from 1.7×10^2 CFU/g to 1.5×10^3 CFU/g during the 5 days of storage under ambient conditions (32°C). The total plate count (TPC) increased from 8.0×10^3 CFU/g to 9.7×10^4 during the storage period of 5 days under the ambient conditions (32°C). In 4th day, the microbial populations exceeded the recommended standard levels thus making the product unsuitable for human consumption. Therefore, the shelf-life of the developed muffin was 4 days under ambient conditions. Accordingly, it can be concluded that Buthsarana flour can be successfully introduced to the bakery industry as an alternative to wheat flour and 100% Buthsarana flour-based muffin with acceptable sensory properties can be successfully developed.

Keywords: Buthsarana, muffin, sensory properties, shelf-life, proximate composition

Introduction

Buthsarana (*Canna edulis* ker.) is one of the underutilized tuber crops native to West Indies and South America although it can also be found in almost all tropical and subtropical regions. There are two varieties of *Buthsarana* based on morphology, namely, 'dark purple' and 'white-green' (Wimala and Balanigum, 2005). The present study used 'dark purple' variety of *Buthsarana* to produce a value-added product. As an edible yam, *Buthsarana* has relatively a high nutritive value and thus contains 75-80% of starch, 6-14% sugar, and 1-3% of protein on dry-basis. Furthermore, *Buthsarana* is a rich source of potassium. *Buthsarana* starch is reported to contain large granules (30-100μm) resulting in fast sedimentation (Hermann, 1996). Further, the chemical compounds found in *Buthsarana* flour can be considered as major sources of antioxidants. The extracts of *Buthsarana* rhizomes are a rich source of polyphenolic compounds such as phenols and flavonoids.

In Sri Lanka, *Buthsarana* yams are used as an Ayurvedic medicine to cure jaundice, phlegm and high blood cholesterol levels. Moreover, *Buthsarana* is used to cure snake bites, especially the bites caused by Sri Lankan krait serpent (Godamulla, 2010). *Buthsarana* yams are mainly consumed by the people in the boiled form. The consumption of this yam is not popular among many people in Sri Lanka because of its low palatability. However, *Buthsarana* yams have a high potential to develop into value-added food products thereby exploiting its herbal and nutritive value. In this study, value addition of *Buthsarana* in the form of muffin (using *Buthsarana* flour) was explored. A muffin can be defined as a type of quick bread that is baked in small portions. Many forms of muffin are similar to small cakes or sponge cakes in shape although they usually are not as sweet as sponge cakes and generally lack frosting. Muffins can mainly be used as a breakfast food during tea time. Preparation of muffin using *Buthsarana* flour would increase the consumption of *Buthsarana* as an alternative food source. Therefore, the objectives of the present study were to explore the possibility of utilizing *Buthsarana* flour in preparation of muffin and to evaluate its physicochemical, sensory and microbiological properties.

Materials and methods

Well-mature, peeled-off *Buthsarana* yam pieces were dried at 65°C for 6 h and flour was prepared by grinding the dried yams. Muffin mixtures containing 25, 50, 75 and 100% (w/w) *Buthsarana* flour were formulated. In the preparation process of muffin, first eggs were beaten and then milk, sugar and vanilla and butter were added to the mix and stirred well. The flour mixture, baking powder and salt were mixed in a separate bowl and liquid ingredients were thoroughly mixed with the rest of the ingredients. Then the batter was poured into the well greased muffin pans and baked at 180°C for 15 min in a pre-heated oven. Muffin samples were compared with 100% (w/w) wheat-flour muffin sample in terms of physicochemical and sensory properties. Sensory properties of muffin samples were determined using a five-point hedonic scale, by 30 untrained sensory panelists. Sensory scores were analyzed using Kruskal-Wallis non-parametric one-way ANOVA using STATISTIX computer software (ver 2.0) for Windows.

Total ash, fat, fiber, pH and protein contents of the developed product were determined using standard analytical techniques (AOAC, 1995). Total ash content of the developed product was determined using a laboratory muffle furnance and fat content was determined using the Soxhlet extraction apparatus. Fiber content was determined according to the enzyme modified neutral detergent fiber method and protein content was determined using the Kjeldhal method (AOAC, 1995). The pH was determined using the pH meter (Cyberscan 2000, Hanna Instruments, Milan, Italy). All the analyses were carried out in accordance with the procedures described by the Association of Official Analytical Chemists (AOAC, 1995) and (Nielsen, 1998). Moreover, the microbiological properties such as Total Plate Count (PCA; Oxoid Ltd, UK) and yeast and mould count (PDA; Oxoid Ltd, UK) were also determined for the developed product. The experiments were conducted in duplicates to draw statistically valid conclusions and a probability value of 5% (=0.05) was used in drawing statistical inferences.

Results and discussion

The sensory properties of the different muffin products are shown in Table 1.

A-100% *Buthsarana* flour muffin, B-75% *Buthsarana* flour and 25% wheat flour muffin, C-50% *Buthsarana* flour and 50% wheat flour muffin, D-25% *Buthsarana* flour and 75% wheat flour muffin, E-100% wheat flour muffin.

Table 1. Estimated mean ranks of the scores given according to the preference for sensory attributes with respect to each formula

Sample	Sensory Attribute				
	Aroma	Color	Taste	Texture	Overall acceptability
A	56.6± 0.831^{b}	41.1±0.86^{a}	112.27±0.84^{a}	133.47±0.78^{a}	118.48±0.77^{a}
B	72.23± 0.98^{b}	65.3±0.96^{b}	75.35±0.89^{b}	36.45±1.08^{a}	67.01±1.12^{b}
C	80.08± 0.97^{b}	122.7±1.21^{a}	68.33±1.18^{b}	76.28±0.98^{a}	79.75±1.14^{b}
D	52.83±0.87^{b}	78.3±1.18^{a}	61.30±0.96^{b}	62.70±1.08^{b}	59.05±0.86^{b}
E	115.73±0.89^{a}	70.2±0.97^{b}	60.25±0.93^{b}	68.60±0.93^{a}	53.20±0.92^{b}

The values are means scores of sensory attributes ± Standard deviation (SD). The means in the each column followed by the same superscript are not significantly different ($p>0.05$).

According to the above results (Table 1), the highest sensory score was recorded by sample A for taste, texture and over-all acceptability. Therefore, the product A (100% *Buthsarana* flour muffin) was selected as the best muffin sample. Moisture, pH, ash, fat, fiber, and protein contents were determined as physicochemical and proximate analyses. According to the results of proximate analysis, *Buthsarana* flour contained 9.3% moisture, 9.6% protein, 1.2% crude fat, 4.3% crude fiber and 1.2% ash. The pH value of the developed product was 6.91. Moreover, 100% *Buthsarana*-flour-based muffin contained 24.8% moisture, 5.8% protein, 18.6% crude fat, 4.8% crude fiber and 1.9% ash.

Yeast and mould counts increased from 1.36 10^{2} CFU/g to 1.5 x10^{3} CFU/g during the storage period of 5 days under the ambient conditions (32°C). The total plate count (TPC) increased from 8.0 x10^{3} CFU/g to 9.7x 10^{4} CFU/g during the storage period of 5 days under the ambient conditions (32°C). In 4th day, the microbial populations exceeded the recommended standard levels thus making the product unsuitable for consumption. Therefore, the shelf-life of muffin was 4 days under the ambient conditions.

Conclusions

It can be concluded that *Buthsarana* flour can be successfully introduced to the bakery industry as an alternative to wheat flour and 100% *Buthsarana* flour-based muffin with acceptable sensory properties can be successfully developed. Moreover, the developed product is microbiologically safe for human consumption for up to 4 days at ambient storage temperature (32°C).

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Development of Carrot (*Daucus Carota* L.) Incorporated Grain Bar and Evaluation of its Quality Parameters

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Abstract

Ready to eat food industry has developed rapidly with the changing life style and the busy schedule of the people. Different varieties of ready to eat foods are gaining popularity in the market and have high demand as healthy convenience foods. Grains and carrot supply energy, protein, vitamin and minerals for human body. Therefore, soybean, green gram, red rice and maize were used to produce a grain bar incorporating dehydrated carrots. The four types of grains were dried at 70°C for 5h, roasted at 80°C for 15 min and ground separately. All the ground grains and dehydrated carrot powder were sieved through 300μm and 500μm meshes to separate two sizes of particles. The grain mixture was prepared by mixing of four types of grain flour, margarine, dehydrated carrot, sugar, salt, vitamin E and water. Desiccated coconut was spread as a layer in the middle of the grain bar and a metal block was used to take the shape of the grain bar. The product was kept in the oven at 70°C for 2.5h to reduce moisture. The best ratio of grains was selected by preliminary tests and 'Samaposha' was the control treatment. Best level of carrot and best particle size were selected through sensory evaluation by using 5 points hedonic scale with 30 semi-trained panelists. Proximate composition of the developed product was determined. Final product was packed by using Low Density Polyethylene (LDPE). Shelf-life of the product was determined at the beginning and in two weeks interval up to 3 months under refrigerated and ambient temperatures. The selected product containing, 25% soybean, 15% green gram, 20% red rice, 20% maize, 10% desiccated coconut and 10% dehydrated carrot, showed high level of acceptance compared to others. The percentage of crude protein, crude fat, ash, crude fiber, moisture, and carbohydrates in the best sample was 20.2, 11.2%, 3.8%, 3.4, 1.5%, 58.9, respectively and the energy value was 430.7 kcal/100gl. According to the results of shelf life analysis for 3 months, microbial count, moisture content, acid value an peroxide value, they were within the recommended levels. The cost reduction of the formulated grain bar compared with an established market product 'Samaposha' was 4%.

Keywords: Carrot, grain bar, sensory properties, shelf-life, Samaposha

Introduction

The global social, economic and demographic changes over recent years greatly influenced the food we eat. As a result, the convenience food sector has grown by 70% over the past decade. Today in Sri Lanka, there are number of grain products are available in the market, especially for babies as well as adults. Grain mixtures can be used to prepare snacks, breakfast meals or any other forms according to the requirement of the customers (Gibson, 1999). As an agricultural country, most of the valuable grains such as rice, maize, sorghum, green gram, black gram are produced in Sri Lanka. Many Sri Lankans prefer low cost food items with high nutritional status (Mahendran and Krishanthi, 2008).

The functional food market grew rapidly during the past few years. Development of healthy, high quality food products are still essential, due to the increasing demand associated with the changes in life-style of consumers. Many people may not spend enough time to prepare their meals. Therefore they try to eat some bakery products and consequently their nutritional condition is becoming poor (Gibson, 1999).

Carrot is a popular root vegetable which contains high amount of beta carotene. The phytonutrients in carrot tap root is reportedly applied for improving the health of skin, hair and nails of human and health of the immune system (Kris, 2012).

The objectives of the present study were to develop and evaluate the quality parameters of a value-added grain bar based on soya bean, green gram, red rice, maize and carrot, and to find out the critical limit of incorporation of dehydrated carrot powder. Cost of the developed grain bar was compared with commercially available 'Samaposha'.

Materials and Methods

Green gram, soybean, red rice, maize, carrot, margarine, sugar, salt and vitamin E were purchased from the local market. The cleaned grains were oven dried at 70°C for 5h. Then they were roasted at 80°C for 15 min and ground well. The preliminary tests were carried out to select the best grain mixture. Sensory evaluations were carried out to select the best level of carrot and best combination of particle sizes. Then the roasted grains and dehydrated carrots were ground and separated in to particle size of ≤300 µm and 300 - 500 µm. Treatment combinations of dehydrated carrot ratios were 5%, 10% and 20% with the acceptable grain mixture. Treatment combinations of particle sizes were ≤ 300 µm, 300-500 µm and the mixture of above two particle sizes in 1:1 ratio. The grain mixture contained four types of grain flour, margarine, dehydrated carrot, sugar, salt, vitamin E and water. Desiccated coconut was prepared by using oven at 121°C for 15 min and then spread as a layer in the middle of the grain bar. A metal block was used to take the shape of the grain bar. The product was kept in the oven at 70°C for 2.5 h to reduce moisture. The final product was allowed to cool, then packed in Low Density Polyethylene (LDPE) and stored for 3 months in both ambient and refrigerated temperatures.

Sensory properties were evaluated using 5 points hedonic scale by 30 semi-trained panelists. The sensory attributes were appearance, colour, smell, texture, mouth feel, taste and overall acceptability. Sensory data were analyzed using Kruskal-Wallis non parametric one-way ANOVA using STATISTIX computer software (Ver. 2.0)

The whole grain bar was ground into fine powder and the proximate composition was analyzed for crude protein, crude fat, total ash, crude fiber and moisture content. Microbiological properties (TPC, Yeast and Mould count), pH value, acid value, peroxide value (AOAC, 2000) and moisture changes were tested at the beginning and in two weeks interval up to 3 months to determine the keeping quality of the products. Microbiological properties were tested in ambient (25 °C- 30 °C) and refrigerated temperatures (<10 °C).

Results and Discussion

According to the sensory evaluation of preliminary tests, the selected sample contained 25% soybean, 20% red rice, 20% maize and 15% green gram.

According to the results of the sensory evaluation for the selection of particle size of the mixture, the sample contained 50% of <300µm particles and 50% of 300 µm-500 µm particles of grains were selected as the most acceptable sample and the selected sample was used to find the best level of dehydrated carrot powder from 5%, 10% and 20% of ratios.

Table 1. Mean ranks for sensory characters of carrot incorporated grain bar and *Samaposha*

Treatment	Appearance	Color	Smell	Texture	Mouth feel	Taste	Overall acceptability
T1	16.2±0.7	15^{c}±0.6	23.07^{b}±0.5	24.4±1.1	20^{b}±0.9	21^{b}±1.1	23^{b}±1
T2	44.3±0.8	29^{bc}±1.1	23.2^{b}±1.0	41.23±0.6	41^{a}±1.0	47^{a}±0.6	48^{a}±0.6
T3	25.3^{bc}±1.2	32^{ab}±0.9	24.23±0.9	31.73±1.1	40^{a}±0.9	28^{b}±1.1	24^{b}±1.2
T4	36.1^{ab}±0.7	46^{a}±0.6	51.5^{a} ±0.3	24.57±1.0	21^{b}±0.7	26^{b}±.0.6	27^{b}±0.7

T1-5% Dehydrated carrot, T2-10% Dehydrated carrot T3- 20% Dehydrated carrot T4- Samaposha.

Means with same superscript letter in the column are not significantly different (P> 0.05) at 5% level.

Obtained sensory data revealed that, 10% of dehydrated carrot level (T2) was the best level for carrot incorporated grain bar.

The proximate composition and energy value of the final product were 1.5% moisture, 3.8% ash, 11.2% crude fat, 20.2% crude protein, 3.3% crude fiber, 58.9% total carbohydrates and 430.67 kcal/100 g, respectively. The developed grain bar has high nutrient value with compared to '*Samaposha*'.

The standard levels of TPC and yeast and mould counts of the grain products are 1×10^4 CFU/g and 1×10^2 CFU/g, respectively (SLSI, 1989). But the observed maximum counts of TPC and yeast and mould counts were 7×10^3 CFU/g and 8.5×10^1 CFU/g, respectively in ambient temperature and 5.5×10^3 CFU/g and 4×10^1 CFU/g in refrigerated temperature. The pH value and acid value of the developed product were 5.8% and 0.0098%, respectively at the end of the storage period. The peroxide value was zero during the storage period.

The cost of production for 100 g of carrot incorporated grain bar was Rs. 33.60 and cost reduction was 4% comparing with the reference market product 'Samaposha' (Rs.35.00/100 g).

Conclusion

Carrot incorporated grain bar with excellent sensory properties can be successfully developed by mixing soya bean 25%, green gram 15%, red rice 20%, maize 20%, dehydrated carrot 10%, desiccated coconut 10%, sugar 8%, salt 2%, margarine 2% and 20 mg of vitamin E. The proximate composition and the energy value of the final product was 1.5% moisture, 3.8%, ash, 11.2%, crude fat, 20.2% crude protein, 3.3% crude fiber, 58.9% total carbohydrates and 430.67 kcal/100g, respectively. When considering microbiological and physicochemical changes, the developed product could be stored for 3 months at the ambient and refrigerated conditions. Cost reduction of the formulated grain bar was 4%, comparing with the same weight of the market available reference product 'Samaposha'.

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Development of Rapid-Cooking Jack Seeds *(Artocarpus heterophyllus* L.*)* for Different Food Applications

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Abstract

Jackfruit, a very famous fruit in rural areas in Sri Lanka, grows everywhere in the country. Jack tree bears fruits seasonally which have a high nutritional value. Now-a-days, most of the people are busy with their day-to-day life style and like to use value-added food items that can be quickly and easily prepared. Traditional method of cooking of jack seeds is a cumbersome and time-consuming task. Therefore, there is a necessity to develop rapid-cooking jack seeds that can be used in preparation of various food dishes. Five kilograms of cleaned jack seeds were kept for 10 days under shade for drying and aging. At the same time, another 5 kg of seeds were obtained as fresh seeds. All seeds were kept in a laboratory oven at 230 °C for 15 min (hot air drying) to make it easy for removal of the seed coat. The jack seeds were soaked in cold water for 6 h and further soaked in 0.5% Sodium bicarbonate for another 6h. After that, soaked jack seeds were kept in the freezer at -18 °C for 8h. After thawing, all the jack seeds were dried in a dryer for 4 h at 70 °C and dried samples were packed using double-laminated packaging materials. Most acceptable two treatment combinations for jack seed preparation were selected after determining the sensory properties of prepared jack seeds on a 5-point hedonic scale using 15 semi-trained panelists. Finalized two treatment combinations were evaluated for sensory properties with a control using Kruskal-Wallis non-parametric one way ANOVA test and the sensory attributes were taste, texture, hardness, smell and overall acceptability. The selected best formulation was tested for microbiological properties, changes in pH and the moisture content to determine the shelf-life. Moreover, the developed product was tested for proximate composition to determine the nutrient composition. The best treatment combination was fresh jack seeds soaked in 0.5% sodium bicarbonate and packed in double-laminated packaging material after double-freezing. The average cooking time of the developed rapid-cooking jack seed was 1 min and 20 sec. The contents of moisture, fat, protein, ash, and crude fiber of the developed product were 4.6%, 0.4%, 5.8%, 1.3% and 1.3%, respectively. The shelf-life of the developed product was more than 2 months considering the sensory, microbiological and physicochemical properties.

Keywords: Jack seed, rapid-cooking, sensory properties, microbiological properties, shelf-life

Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is a popular fruit crop that is widely grown in Thailand and other tropical areas (Gunasena, 1993). The ripe fruit contains well-flavored yellow sweet bulbs and seeds that are embedded in the bulb. The edible bulbs of ripe jackfruit are consumed fresh or processed into canned products. Seeds make-up around 10% to 15% of the total fruit weight and have high carbohydrate and protein contents (Kumar, 2010). Seeds are normally discarded during the fruiting season. Otherwise, seeds are steamed and eaten as a snack or used in some local dishes. Although fresh seeds cannot be kept for a long time, seed flour can be kept for a long time. Accordingly, seed flour can be used to develop different value-added food products.

The tender jack fruit is a popular vegetable and used in making soup and pickles. The juicy pulp of the ripe fruit is eaten fresh or preserved in syrup which has a wide potential for preparing jam, jelly *etc.* The juicy pulp, having high amounts of pectin, is used in the preparation of numerous value-added food products. The seeds are generally eaten in boiled or roasted form or used in many culinary preparations as it contains a similar nutrient composition like grains (Ariyadasa *et al., 1996)*. As jack fruit is highly seasonal and seeds have a short shelf-life, the fruit is wasted during the fruiting season. Rapid-cooking jack seeds can be used to make different food dishes such as curry, *Aggala*, bites, and fried seeds. Now-a-days, most of the people prefer to use value-added food items that can be quickly and easily prepared. Traditional method of cooking of jack seeds is a cumbersome and time-consuming task. Therefore, there is a necessity to develop rapid-cooking jack seeds that can be used in preparation of various food dishes. Therefore, the objectives of the present research were, to develop rapid-cooking jack seeds for different food applications, to evaluate the physicochemical and sensory properties of the developed product, to determine the cooking time of the developed product, to evaluate the shelf-life of rapid-cooking jack seeds and to analyze cost and benefits of rapid-cooking jack seed.

Materials and methods

After opening the jack fruit with a large knife, seeds were separated from the fleshy sheaths that enclose the seeds. Five kilograms of jack seeds were kept for 10 days under shade for drying and aging. Another 5 kg of jack seeds were obtained as fresh seeds. All seeds were kept in a laboratory oven at 230 °C for 15 min for air drying to make removal of seed coat much easier. These seeds were used in the research study. Eight types of jack seed samples were prepared using three variables such as type of seeds, soaking time, freezing treatments (Table 1). Except above variables, all the other conditions of samples remained constant. The treatments included soaking without sodium bicarbonate in cold water for 6 h (A_0), with 0.5% Sodium bicarbonate for 6 h (A_1), single freezing at -18 °C (B_0), double freezing -18°C (B_1)], fresh seeds (C_0) and aging seeds for 10 days under shade (C_1) (Table 1).

All treated samples were dried at 70°C using a kerosene dryer (UM/ULM/SLM 800, New York, USA) which was used in noodles processing at Harischandra Mills PLC in Matara until water was removed to obtain a specific weight without cracks in seeds. After drying, samples were kept in desiccators for cooling. Dried Jack seed samples were packed in double-laminated packing material and labeled. All samples were stored in a cool dry place at room temperature until further testing.

Table 1. Treatment combinations used for production of rapid-cooking jack seeds

Treatment No.	Treatment combinations	Sample code
1	Cold water soaking, Single freezing, Fresh seeds	$A_0B_0C_0$
2	Cold water soaking, Double freezing, Fresh seeds	$A_0B_1C_0$
3	Sodium bicarbonate soaking, Single freezing, Fresh seeds	$A_1B_0C_0$
4	Sodium bicarbonate soaking, Double freezing, Fresh seeds	$A_1B_1C_0$
5	Cold water soaking, Single freezing, Aging seeds	$A_0B_0C_1$
6	Cold water soaking, Double freezing, Aging seeds	$A_0B_1C_1$
7	Sodium bicarbonate soaking, Single freezing, Aging seeds	$A_1B_0C_1$
8	Sodium bicarbonate soaking, Double freezing, Aging seeds	$A_1B_1C_1$

The most acceptable treatment combinations for jack seed preparation was selected after determining the sensory properties of prepared jack seeds using 15 semi-trained panelists on a five-point hedonic scale. Finalized treatment combinations were evaluated for sensory properties with a control using Kruskal-Wallis non-parametric one-way ANOVA and the sensory attributes were taste, texture, hardness, smell and overall acceptability. The selected best formulation was tested for microbiological properties, changes in pH and moisture content to determine the shelf-life. Further, the developed product was tested for proximate composition to determine the nutrient composition.

Results and discussion

Sensory results obtained from sensory evaluation of two types of treatment combinations with control treatment are summarized in Table 2.

Table 2. Sensory scores for the selected best treatment used to produce jack seeds

Treatment	Taste	Texture	Hardness	Smell	Overall acceptability
A	28.2±0.48^{a}	30.4±0.41^{a}	26.8±0.61^{a}	27.5±0.35^{a}	29.3±0.48^{a}
B	25.4±0.51^{ab}	29.2±0.45^{a}	25.3±0.94^{a}	24.5±0.45^{a}	28.0±0.50^{a}
C	15.4±0.70^{b}	9.4±0.70^{c}	16.9±0.91^{a}	17.0±0.50^{a}	11.7±0.48^{c}

A-Fresh seeds, sodium bicarbonate soaking and double-freezing
B-Aged seeds, sodium bicarbonate soaking and double-freezing
C-Control treatment (fresh seeds, cold water soaking and single-freezing)
Means with same superscript letters are not significantly different (P> 0.05) from one another

There are two treatment combinations (A & B) where means are not significantly different (p>0.05) from one another for overall acceptability (Table 2). Sample C is significantly different (p<0.05) from sample A and B. Treatment A has recoded the highest mean rank sum for each sensory attribute and was selected as the best formulation. Further, treatment A had the lowest average cooking time compared to treatment B and the control. Treatment A which was fresh seed treated with sodium bicarbonate showed a cooking time of 1 min and 20 sec. Low total solid in gruel percentage is a desirable quality in the food product. Treatment A produced low gruel percentage (3.95%) in jack seeds compared to treatment B. Contents of moisture, fat, protein, ash, and crude fiber of the developed product were 4.65%, 0.39%, 5.87%, 1.25% and 1.33%, respectively.

The total plate count (TPC) immediately after production of jack seeds was 3.4×10^{2} CFU/g. After 2 months, TPC of the developed product increased to 5.2×10^{2} CFU/g. The population level of total plate count should be less than 10^{4}CFU/g for a dry food product (Sivasankar, 2007). After 2 months, the population level of TPC did not exceed that safety level in rapid-cooking jack seed. Yeast and mould count at the initial level of the developed product was 3.9×10^{1} CFU/g. After 2 months, yeast and mould count of the developed product increased to 4.5×10^{1} CFU/g. The population level of yeast and mould of the developed product did not exceed the safety level of 10^{2} CFU/g for a dry food product suggested by Sivasankar (2007).

Favorable pH limit of a food is neutral which is around seven. During 2 months of storage, the pH value of the developed product decreased from 7.23 to 6.93. Recommended safety limit of moisture content is less than 14% or else microbial spoilage may occur. During 2 months storage time period, moisture content of the developed product increased from 4.62% to 5.36%. The estimated production cost of rapid-cooking jack seed was Rs. 62.00/kg.

Conclusions

The best treatment combination for jack seed preparation was fresh seeds treated with 0.5% sodium bicarbonate and double-freezing at -18 ºC for 8 h. Sodium bicarbonate appeared to result in softening the jack seeds, thereby facilitating fast cooking. Freezing appeared to ensure even-cooking and rapid-cooking. The contents of moisture, fat, protein, ash, and crude fiber of the developed product were 4.6%, 0.4%, 5.8%, 1.3% and 1.3%, respectively. Average cooking time of the developed product was 1 min and 20 sec. It was a 86.7% time saving compared to cooking of jack seeds by boiling with water. The shelf-life of the developed product was more than 2 months considering the sensory, microbiological and physicochemical properties. Further analysis needed to be carried out to evaluate the shelf-life of the developed product. The production cost of 1 kg of rapid-cooking jack seed was Rs. 62.00.

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Development of Herbal Cheese Using Curry Leaves *(Murraya Koenigii Spreng.)* and Determination of its Quality Parameters

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Abstract

Cheese is a nutrient rich food that can play an important role in the human diet. Curry leaves *(Murraya koenigii Spreng.)* is widely used as a flavor enhancer in curry preparations. Further, curry leaves have been used as a herbal medicine in Sri Lanka for centuries. The objective of the present study was to develop a herbal cheese incorporated with curry leaves and determine its quality parameters. Three forms of curry leaves; juice, air-dried and oven-dried curry leaves were evaluated by 30 untrained sensory panelists on a five-point hedonic scale. The sensory properties (appearance, aroma, texture, mouth feel, flavour and overall acceptability) of different forms of curry leaves were analyzed using Kruskal-Wallis non parametric one-way ANOVA. The proximate composition of the selected product was determined using standard analytical techniques. Furthermore, microbiological (aerobic plate count, yeast and molds) and physico-chemical properties (pH, titratable acidity) were also determined during storage of herbal cheese at 4°C. Out of three forms of curry leaves, oven-dried form was selected as the best form as it showed significantly ($P<0.05$) higher sensory properties compared to other forms. Cheese incorporated with 0.2% (w/v) oven-dried curry leaves with whole milk (11%), starter culture (0.04g), rennet enzyme (0.3g) and salt (2.5g) was selected as the best cheese sample as it showed significantly ($P<0.05$) higher sensory properties. The moisture, total solid, protein, fat, fiber, and ash contents of the selected product were 42.6%, 57.4%, 19.7%, 31.2%, 1.17% and 2.6%, respectively. Based on the changes in microbiological and physico-chemical properties, shelf-life of the product was 21 days. It was concluded that Curry leaves can successfully be incorporated into cheese to produce a value-added cheese with improved sensory properties.

Keywords: Curry leaves, Herbal cheese, Sensory properties, Shelf-life, Microbiological properties

Introduction

Cheese is a fermented milk-based food product having a great diversity in flavours, textures and forms (Lampert, 1970). Cheese is made from the curd taken from the milk, skimmed milk or partly skimmed milk, butter milk or in any combination of them. Cheese can be consumed either fresh or at different stages of ripening (SLSI, 1987). Generally, cheese consists mainly of fat and casein and a relatively small amount of water soluble constituents such as whey protein, lactose and water soluble vitamins. Although cheese is a nutrient rich food, the exact nutritional composition depends on the type of milk used, manufacturing and ripening procedures (Fox *et al.,* 2000).

Curry leaf plant (Murraya koenigii Spreng.) belongs to the family Rutaceae. It is a native plant to India and Sri Lanka. Curry leaves are mainly used as a flavor enhancer in Eastern cuisine. Traditionally, curry leaf has been used as a medicine since historic times. Leaves are used to cure dysentery and to stop vomiting whereas root juice is used as a pain reliever in kidney disorders (Jayasinghe, 1999). They are also used to cure skin eruptions and the bites of poisonous animals. Furthermore, curry leaf plant has showed pharmacological activities such as cholesterol reducing property, antidiabetic property, antimicrobial activity, antiulcer activity, hepato-protective activity

(Ajay et al., 2011). The objective of the present study was to develop a herbal cheese incorporated with curry leaves and to determine its quality parameters.

Materials and methods

Curry leaves (Murraya koenigii Spreng.) were obtained from the local market and cleaned using clean water. Cleaned curry leaves were ground well using a mortar and pestle with 50ml of distilled water in the laboratory. Juice was separated from the prepared slurry using a cheese cloth. In addition, curry leaves were cut into small pieces and oven dried at 55-60 °C for 1 to 1.5 h to prepare oven-dried curry leaves. Another portion of curry leaves was cut into small pieces and dried under shade for a day. Fresh milk was pasteurized at 72 °C for 15 sec using a waterbath and cooled to 31-33°C. Egg yolk powder was dissolved in hot water and added to the milk. Mesophilic bacterial starter culture was added to the mix and the mix was kept for the fermentation process for 20-50min. Pre-prepared various forms of curry leaves as described before were added to the milk and control sample was kept without any form of curry leaves. Rennet enzyme was added to the milk and the mix was stirred well. The fermenting mix was kept undisturbed for 20-50 min for coagulation. After coagulation, curd was cut into cubes of 3-5 cm^3 using a clean knife. Curd was kept in the fermenting pan for 10-20 min. Curd was stirred at 37-41°C for 20-30 min until the whey is removed from the curd. Whey portion was separated from the curd using a cheese cloth. After the whey removal, salt was added to the curd and the whole mix was well mixed. Curd was moulded using a laboratory prepared clean cheese mould. Different levels of oven-dried curry leaves (0.1, 0.2, 0.3 and 0.4%; w/v) were used to produce herbal cheese. Finally, cheese was stored in a refrigerator and sampling and analysis were carried out during storage for four weeks. Prepared herbal cheese incorporated with curry leaves were subjected to sensory evaluation by 30 untrained panelists on a five-point hedonic scale. Sensory data were analyzed using Kruskal-Wallis one-way ANOVA test with STATISTIX (version 2) computer software for Windows.

The moisture content of the developed product was determined using oven-dry method whereas the total ash content was determined using a laboratory muffle furnace. The fat content was determined using the Gerber method while fiber content was determined according to the enzyme modified neutral detergent fiber method (AOAC, 2002). The protein content was determined using Kjeldhal method. All the analysis was carried out in accordance with the procedures described by the Association of Official Analytical Chemists (AOAC, 2002). The pH and titratable acidity of the product were also measured during the storage period. The pH was measured using a pH-meter (HI98120, Hanna Instruments, Milan, Italy). Titratable acidity was expressed as a percentage of lactic acid and was determined by titration of a water solution of 10 g

Different forms of curry leaves	Sensory scores					
	Appearance	Aroma	Texture	Mouth feel	Flavour	Overall acceptability
Oven-dried	71.5^a	80.0^a	69.8	68.7	75.4^a	81.0^a
Air-dried	73.6^a	64.7^{ab}	63.4	70.0	72.0^a	72.5^a
Juice	54.8^{ab}	54.1^b	62.4	51.0	53.1^{ab}	47.5^b
Control	40.5^b	43.2^b	46.4	52.2	41.4^b	41.0^b

Means with same superscript are not significantly different (P>0.05) from one another.

of cheese with 0.1 N NaOH using phenolphthalein as an indicator. Moreover, the total plate count (PCA; Oxoid Ltd., UK) and the yeast and mould count (PDA; Oxoid Ltd., UK) of the developed product were also determined according to SLSI specifications.

Results and discussion

The results of the sensory evaluation of herbal cheese prepared using different forms of curry leaves are presented in Table 1.

The highest sensory scores for aroma, texture, flavour and overall acceptability were recorded by the cheese sample incorporated with oven-dried curry leaves (Table 1). However, the cheese sample incorporated with air-dried curry leaves recorded the highest sensory scores for appearance and mouth feel. But there were no significant differences (P>0.05) between mean rank values of air-dried form and oven-dried form for appearance and mouth feel (Table 1). The results of the sensory evaluation of herbal cheese prepared using different levels of oven-dried curry leaves are presented in Table 2.

Herbal cheese incorporated with 0.2% (w/v) of oven-dried curry leaves contained 42.6% of moisture, 57.4% of total solid, 31.2% of fat, 19.7% of protein, 2.6% of ash and 1.17% of crude fiber. The pH value of the initial product was 5.97 and titratable acidity was 0.33%. These observed values were within the SLSI standards (SLSI, 1987) for cheese. During storage at 4°C, pH value of the developed product decreased over the storage time. These results are in agreement with the results of a similar study carried out by Perveen et al. (2011) which reported reduction of the pH value with the storage period in refrigerated conditions. Starter bacteria convert lactose into lactic acids thereby increasing the acidity of the cheese. Titratable acidity is calculated in terms of percent lactic acid. Titratable acidity of the developed product in the present study increased during storage time. Aerobic Plate Count (APC) of the product, immediately after production, two weeks, three weeks and four weeks after production were 3.9×10^3, 7.9×10^3, 9.9×10^3 and 7.0×10^5 CFU/g, respectively. Yeast and mould count of the product, immediately after production, two weeks, three weeks and four weeks after production 2.5×10^1, 1.6×10^2, 1.9×10^2 and 3.8×10^2 CFU/g, respectively. The highest sensory scores for appearance, texture, flavour and overall acceptability was recorded by the cheese sample incorporated with 0.2% (w/v) of oven-dried curry leaves. Although cheese sample incorporated with 0.1% (w/v) of curry leaves recorded the highest sensory scores for aroma and mouth feel the differences between the two products were not significant (P>0.05) (Table 1). Therefore, herbal cheese incorporated with 0.2% (w/v) oven-dried curry leaves was selected as the most acceptable formulation in herbal cheese production.

Table 2 Sensory scores of herbal cheese incorporated with various levels of oven-dried curry leaves

Level of oven-dried curry leaves (w/v)	Sensory scores					
	Appearance	Aroma	Texture	Mouth feel	Flavour	Overall acceptability
0.1%	70.1^{a}	68.2	76.5^{a}	79.7^{a}	61.4^{a}	70.9^{a}
0.2%	86.3^{ab}	62.5	78.4^{a}	71.5^{a}	83.5^{ab}	90.2^{ab}
0.3%	50.9^{bc}	54.4	48.4^{b}	43.9^{b}	49.4^{b}	47.5^{bc}
0.4%	34.7^{c}	56.9	38.7^{b}	44.4^{b}	45.0^{b}	33.4^{c}

Means with same superscript are not significantly different (p>0.05) from one another

Conclusions

Curry leaves can be used successfully to produce herbal cheese. Incorporation of 0.2% (w/v) of oven-dried curry leaves can be recommended as the best level of curry leaves in preparation of herbal cheese. The contents of moisture, total solids, ash, fat, protein and fiber of the developed product were 42.6%, 57.4%, 2.6%, 31.2%, 19.7% and 1.17%, respectively. The pH value and the titratable acidity of the developed product were 5.97 and 0.33%, respectively. Shelf-life of the herbal cheese incorporated with curry leaves was 3 weeks.

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Development of a Nutritious Sponge Cake using Finger Millet, Soybean and Corn Flour

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Abstract

Protein energy malnutrition and micronutrient deficiencies have been persistent health challenges in Sri Lanka. Eventhough there are many types of locally available nutrient rich pulses and cereals, they are underutilized mainly due to lack of suitable processing techniques for value addition. Therefore, the present research was designed to develop a nutrient enriched sponge cake at low cost so that the product can be attracted by children as a nutrient supplement. Sponge cake was produced using finger millet, corn flour and soy flour. Through a preliminary study, 10% (w/w) soy flour was selected as the best level to produce sponge cake without compromising the sensory properties of the final product. Four formulations were developed for the sensory evaluation to select the best mixing ratio of flour and the sponge cake produced with 100% (w/w) finger millet flour was used as the control. Sensory data were analyzed using Kruskal-Wallis one-way ANOVA. There was no significant difference ($P>0.05$) between five samples in the tested sensory parameters. Therefore, the sample with 60% finger millet, 30% corn and 10% soy flour (w/w) that recorded the highest mean ranks for sensory properties was selected as the best sample. The proximate analysis and the shelf-life analysis were conducted for the developed sponge cake. The developed product contained 20.4% moisture, 9.7% crude protein, 24.8% fat, 3.6% ash, 1.1% crude fiber and 40.2% carbohydrates. The developed sponge cake was safe to consume for five days as the microbial counts were within the acceptable levels only for five days. This low cost nutritious cereal-based sponge cake was highly acceptable to consumers and thus can be introduced to the society as an alternative for the wheat flour based muffin.

Keywords: Corn, Finger millet, Soybean, Sensory properties, Sponge cake

Introduction

Sri Lanka has made great strides to improve the health sector of the country, but child malnutrition has been a persistent health challenge (USAID, 2006). Protein energy malnutrition and micronutrient deficiencies are the most serious nutritional problems dominant in the country. Therefore, the improvement of the nutrient content of specific food items, based on the dietary habits and nutritional status of children is one of the most important nutritional interventions for improving the children's nutritional status.

A large shift from consumption of coarse grains to more refined cereals can be observed among the urban population and higher income groups, which leads to a significant decrease of overall nutrient content in the diet (Vijayakumar and Mohankumar, 2009). A relatively small increase in grain composition has the potential to ensure significant health gains when they are incorporated into food. Although millets are high in nutritive value, their utilization in the country is not widespread. They are mostly used in preparation of traditional dishes. Therefore, finger millet can be mixed with legumes after suitable processing to extend their utilization (Vijayakumar and Mohankumar, 2009). Composite flour is a mixture of cereals and legumes to improve the nutritional and functional properties of flours. Soybean is a legume which is considered an excellent source of protein. The usefulness of the grain legumes in developing high-protein foods are now well recognized (Banureka and Mahendren, 2009). Corn is a cereal and is widely used in both the food and feed industries as it contains high amount of nutrients. Cereals are the prime source of energy, but relatively low in total protein content. This deficiency can be overcome by appropriate bending of cereals with legumes (Potter and Hotchkis, 1998).

Several types of supplementary foods have been developed based on cereals and legumes using different technologies. The objective of the present study was to develop a nutritious sponge cake using finger millet, soybean and corn flour.

Materials and methods

Commercially available finger millet flour, dried soybean seeds and dried corn grains were purchased from market. Soybean flour and corn flour were prepared using dried corn grains and soybean seeds. Using trial and error method 10% (w/w) of soy flour was selected as the best proportion to produce sponge cake without compromising the taste of the final product. According to the sensory properties of the final product in the preliminary trial, 50% of finger millet, 40% of corn and 10% of soybean flour were selected as the best initial mixing ratio of flour mixture to produce the sponge cake. Four different formulations were developed to select the suitable composition of ingredients to produce the sponge cake. Treatment 1 (A) contained 60% finger millet, 30% corn and 10% soy flour while Treatment 2 (B) contained 55% finger millet, 35% corn and 10% soy flour. Treatment 3 (C) contained 50% finger millet, 40% corn and 10% soy flour while Treatment 4 (D) contained 45% finger millet, 45% corn and 10% soy flour. The control sample contained 100% finger millet flour.

Margarine (100 g) and powdered sugar (80 g) were creamed separately. Sieved flour mixture, baking powder (5 g) and eggs (2) were added into the mix and creamed thoroughly. Batter was poured into muffin cups and baked at 180°C for 20 min. The sensory attributes such as appearance, texture, taste, smell and overall acceptability were evaluated by 20 semi-trained panelists on a five-point hedonic scale. Sensory data were analyzed using Kruskal-Wallis non-parametric one-way ANOVA. The sample which recorded the highest mean rank for sensory attributes was selected as the best sample and its proximate composition and shelf-life were determined.

The moisture, ash, protein, fat and fiber contents of the sponge cake were determined according to the standard AOAC (2000) methods. The carbohydrate content was determined by calculated as the difference from other nutrients and caloric value was estimated by multiplying the proportion of protein, fat and carbohydrates by their respective physiological energy values. Microbiological analysis was done for the developed sponge cake which was stored at ambient temperature, 25°C in the sealed plastic container in order to determine the shelf-life of the developed product.

Results and discussion

According to the sensory properties of the developed sponge cake samples, T_1 showed the highest mean rank for all the sensory attributes (Figure 1). However, there were no significant differences ($P>0.05$) among all the samples for their sensory attributes. Therefore, the composite flour mixture of 60% finger millet, 30% corn and 10% soybean flour was selected as the best flour mixture to produce a sponge cake which can be attracted by children.

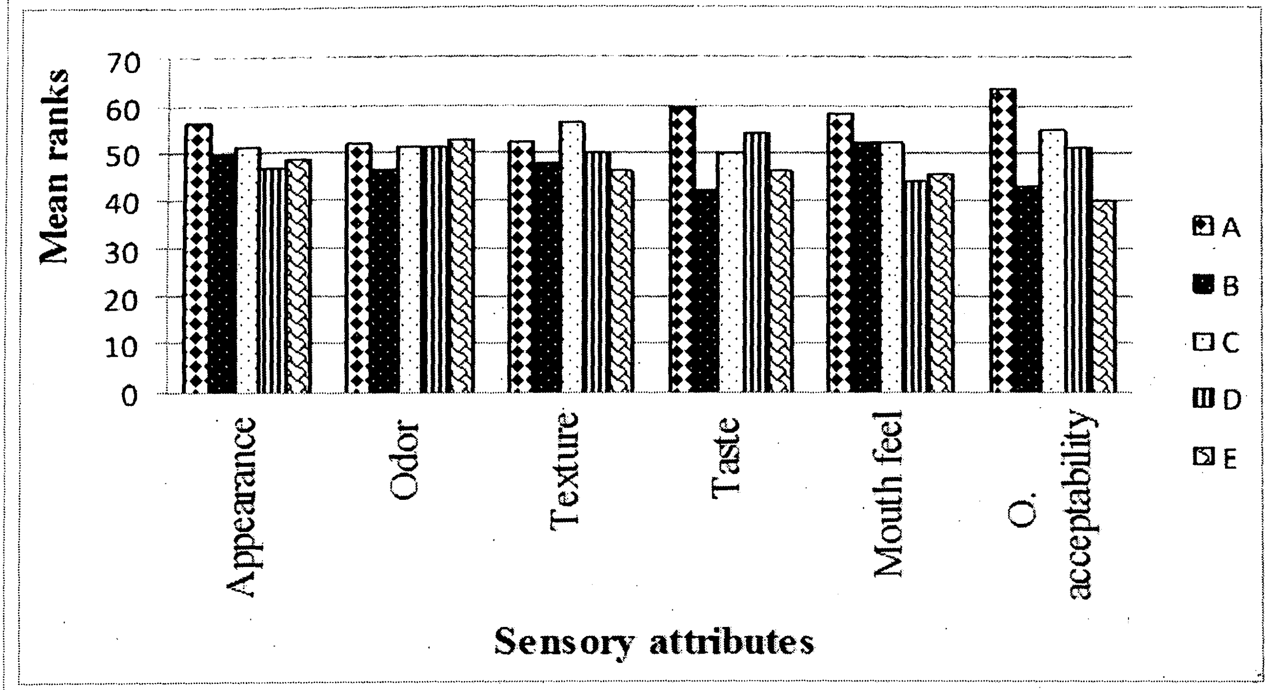

Figure 1. Mean ranks values for the sensory attributes of the samples
A-60% finger millet, 30% corn and 10% soy flour, B-55% finger millet, 35% corn and 10% soy flour, C- 50% finger millet, 40% corn and 10% soy flour, D-45% finger millet, 45% corn and 10% soy flour, E- 100% Finger millet flour.

According to the nutrient analysis, 100 g of developed sponge cake contained 20.4% of moisture, 3.6% of ash, 24.8% of fat, 1.1% of crude fiber, 9.8% of crude protein and 40.2% of carbohydrates. Soybean is a high protein legume and incorporation of soy flour inevitably increases the protein content of the sponge cake. Addition of soy flour also increases the fat and the essential amino acid contents thereby having a greater potential in overcoming protein caloric malnutrition in the world (Akubor and Ukwuru, 2005). The developed sponge cake (100g) provided 437 kcal of energy. Average weight of the sponge cake was 30 g and, accordingly, one sponge cake supplies 131 kcal of energy and also 3 g of protein to the consumer. According to the recommended energy requirements, 4 to 6 years old children require 90 kcal of energy per kilogram of body weight. Thus, a child of 4 to 6 years old with 13 kg of average body weight requires 1170 kcal of energy per day. Therefore, one developed sponge cake provides 11% daily energy requirement of children in this age group. Further, 100 g of sponge cake supplies 37% daily energy requirement.

Number of yeast and moulds and total plate counts of the developed sponge cake were determined during the storage time. Numbers of yeast and moulds counts were less than 10 CFU/g up to five days. Moreover, the number of total microbial population was less than 3×10^2 CFU/g. According to the SLS standards for cereal based products, the acceptable range of yeast and moulds is 10^2-10^4 CFU/g and the acceptable range of total plate counts is 10^5-10^6 CFU/g. The microbial counts observed in the developed product were well within the acceptable range. Therefore, it can be concluded that the product is safe for human consumption for five days of storage period at ambient temperature. If the composite flour mixture is used properly under sanitized baking conditions, the majority of yeast/moulds and bacterial may not survive.

Conclusions

The developed nutritious sponge cake mixture is a consumer-acceptable low-cost product with a good nutrient profile. The nutritious sponge cake can be successfully developed using 60 % finger millet flour, 30% corn flour and 10% soybean flour and is safe for human consumption for five days period from the date of manufacture. Hundred grams of formulated sponge cake mixture contains 375 kcal of energy and 9.8 g of protein. Therefore, this product is a good source for energy and protein for consumers. Hundred grams of composite flour mixture can be used to produce 10 sponge cakes. The production cost of 30 g of sponge cake was Rs. 12. The market price of a similar wheat-flour-based product is Rs. 20. Therefore, production of this food item is more profitable compared to wheat-flour-based muffins.

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Development of Mushroom *(Pleurotus ostreatus)* Curry Balls and Determination of its Quality Parameters

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Abstract

Mushrooms are fleshy in nature and posses high nutrient content. Oyster mushrooms (*Pleurotus ostreatus*), the most popular mushroom type among Sri Lankan communities have noted a limited shelf-life. Therefore, the scientific attention has been drawn to value addition, product diversification and different preservation techniques for increase the utilization as well as its shelf-life. The objective of this study was to develop a ready to eat oyster mushroom curry ball. Mushrooms were prepared with four different samples in flavoured (chicken) and non-flavoured types at its fresh and dry powder forms. Uniform spice mixture was added and corn flour was used as the main binding agent. Samples were evaluated by 30 un-trained panellists for colour, flavour, texture, appearance and overall acceptability using 5-point hedonic scale. The selected best sample was packed in two different types of packaging materials; Aluminium foil and Polyethylene, and packs were stored at -18°C for 3 months. The proximate composition of the selected sample and the fresh mushroom were determined according to the standard methods of Association of analytical chemist (AOAC). Microbiological tests on the developed product were conducted at the processed date and three months after processing. According to the proximate analysis, the best sample contained an average moisture, crude protein, crude fat, crude fiber and ash content of 63%, 11.02, 5.2%, 9% and 2.4%, respectively. At initial level the total plate counts and yeast and mould counts in Aluminium foil and Polyethylene packs were 7.273×10^1 CFU/g, 11.364×10^1 CFU/g, 5.000×10^1 CFU/g and 7.727×10^1 CFU/g, respectively. After 3 months, colony counts were 31.364×10^2 CFU/g, 43.182×10^2 CFU/g, 18.636×10^2 CFU/g and 23.182×10^2 CFU/g, respectively. Those values were below the standard limits. Finally it can be concluded that the prepared mushroom curry balls can be readily used in a diet as a nutritious food with improved sensory characters..

Keywords: Mushrooms, oyster mushrooms, Curry ball, quality parameters

Introduction

Mushrooms are reproductive structure of edible fungi which are being used as food and medicine since times immoral. They are excellent source of proteins, vitamins and minerals (Prakash and Tejaswin, 1991). They have shelf-life of less than a day under ambient conditions (Lalkaushal and Sharma, 1995). Therefore, it is important to study as to how shelf life of can be extended in fresh or processed forms.

Due to change of life-styles, increase of disposable income and time restriction for meal preparation, consumers demand convenient, safe and high quality Ready-To-Eat (RTE) foods. Therefore, the food industry is hard-pressed to develop convenient products that are safe, nutritious, and available at reasonable prices.

Acceptability of mushroom in Sri Lanka is limited to small group of consumers because of its characteristic flavour, meaty texture and a general suspicious fact that some of them being poisonous due to lack of awareness. As mentioned by Jayathunga and Illeperuma (2001) mushroom contains 90% moisture and the rate of respiration from the surface is very high. These conditions make them highly perishable in nature.

Low food production due to limited land resources coupled with poor quality of protein is creating a protein gap at alarming rate in many of the developing countries. To increase the shelf life and consumption of mushroom, the income of the growers and the employment opportunities, there is an urgent need to develop new value added mushroom products. One such attempt would be the preparation of oyster mushroom curry ball.

Mushroom curry ball is a great convenience to restaurants, hotels and household as one can just put few balls in the gravy and serve the food within 10 minutes of time.

Therefore, the general objective of the present study was to develop oyster mushroom curry ball. The specific objectives of the study were to determine the quality parameters of oyster mushroom curry ball, to study the effect of the form of mushroom (fresh or dry powder) on the sensory properties of the oyster mushroom curry ball and to determine the shelf-life of oyster mushroom curry ball.

Methodology

The mushrooms were washed, cleaned well and cut in to small pieces. They were blanched in boiled water for 3 minutes and drained off. Mushroom were squeezed to remove excess water and then ground and kept in a pressure cooker up to 5 min after the first whistle. At the same time corn flour and margarine were mixed well by using a blender. Onion, salt, flavour and spices (Curry leaves, Pepper, Garlic, Clove and Cardamom) were added and mixed well to get a fine texture. Then the mushrooms were added and mixed well. After few minutes, the small portions of the mixture were taken and small balls were formed. Prepared mushroom curry balls were kept in a pressure cooker up to 15 minutes after the first whistle. Finally, the mushroom curry balls were mixed well with raw spice mixture by using vinegar. Same procedure was followed for the production of mushroom curry ball by using dry mushroom powder (Dry mushroom powder available at Plywood Manufacturers (Pvt) Ltd).

Thirty un-trained panellists evaluated the samples of mushroom curry ball for colour, flavour, texture, appearance and overall acceptability by using 5-point hedonic scale. Obtained data were analyzed using Kruskal-Wallis one-way ANOVA nonparametric. The selected sample, which was packed in two different types of packaging materials; Aluminium foil and Polyethylene were stored at -18°C for 3 months.

The proximate analysis was conducted for the selected sample and the fresh mushroom to determine, the content of crude protein, crude fat, total ash, crude fiber and moisture according to the standard methods of AOAC.

Table 1. Mean ranks for sensory characters of different formulations

Formulation	Color	Texture	Flavor	Appearance	Overall acceptability
A	89.65^{a}	95.23^{a}	83.93^{a}	84.03^{a}	91.05^{a}
B	62.35^{b}	69.23^{b}	82.48^{a}	70.53^{ab}	72.15^{ab}
C	56.48^{bc}	48.70^{bc}	50.16^{b}	55.43^{bc}	49.95^{bc}
D	33.51^{c}	28.83^{c}	25.41^{c}	32.00^{c}	28.85^{c}

A-fresh mushroom with chicken flavour, **B**-fresh mushroom without chicken favour, C-dry mushroom powder with chicken flavour, D-dry mushroom powder without chicken flavour. Values with the same letter in columns are not significantly different (P > 0.05)

The microbiological tests (Total Plate Counts and Yeast and Mould counts) on the developed product were conducted at the processed date and three months after processing.

Results and Discussion

Table 1 shows the results of the mean rank obtained for colour, flavour, texture, appearance and overall acceptability of different formulations (A, B, C, and D) of mushroom curry ball.

According to the results (Table 1), the highest sensory scores for all sensory attributes were recorded by formulation A (fresh mushroom with chicken flavour) and it was significantly different ($P<0.05$) from other formulations. According to the comments given by the panellists, formulation A was the best among other samples. Therefore, formulation A was selected as the standardized formulation for mushroom curry ball.

Moisture content of the fresh mushroom was 90.3% and it was reduced to 63% in the selected mushroom curry ball sample. Squeezing after blanching in boiling water could be the reason for this reduction. However, this condition helped to control microbial growth, enzyme activity thus prolonging the shelf-life of the developed product.

Crude protein, crude fiber and ash content has been reduced from 22.9%, 19.7% and 7.6% (fresh mushroom) to 11.0%, 9% and 2.4% (mushroom curry ball) respectively. This could be due to removal of watery part during blanching and squeezing before preparation of the curry ball. Further crude fat content has increased from 1.4% to 5.2% in the curry ball with the incorporation of margarine in the preparation process.

Total plate count and yeast and mould count were analyzed to determine shelf-life and hygienic conditions during processing. Total plate counts and yeast and mould counts were minimal and within the acceptable limit. Therefore, the mushroom curry ball can be stored successfully up to 3 months without preservatives. The total plate count and yeast and mould in Aluminium foil and Polyethylene at initial level were 7.273×10^1 CFU/g, 11.364×10^1 CFU/g, 5.000×10^1 CFU/g and 7.727×10^1 CFU/g respectively. The total plate count and yeast and mould in Aluminium foil and Polyethylene at after 3 months were 31.364×10^2 CFU/g , 43.182×10^2 CFU/g, 18.636×10^2 CFU/g and 23.182×10^2 CFU/g, respectively.

Conclusion

The mushroom curry ball was successfully developed using fresh mushroom, corn flour, margarine, onion, spices and flavour. The developed product gave significantly higher values for the sensory properties such as colour, taste, flavour, appearance and overall acceptability. Proximate composition of the developed product was determined as crude protein 11.0%, moisture 63%, ash 2.4%, crude fat 5.2% and crude fiber 9%. The shelf-life of the product was 3 months at -18°C. Finally it can be concluded that the mushroom curry ball can be readily used in a diet as a nutritious food.

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Production of Herbal Butter Incorporated with Ginger (*Zingiber Officinale* L.) and Evaluation of its Antioxidative Properties

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Abstract

Lipid oxidation that limits the shelf-life is among the major problems faced by the butter manufacturers. Potential health hazards of synthetic antioxidants in butter have been reported. The antioxidant properties of ginger have been well researched and documented. Therefore, the objective of the present study was to evaluate the anti-oxidative potential of ginger on the storage stability of butter. Butter samples were incorporated with ginger oil in 0.54, 0.68, 0.82, 0.96, and 1.10 percentages (v/v) and the most acceptable concentration was determined using a sensory evaluation with 30 untrained sensory panelists. In each treatment, 3 butter blocks were used as replicates. The selected three butter samples were stored at 4 °C for the 10-week storage period. Selected three samples were analyzed for free fatty acids (FFA), peroxide value (PV) and microbiological populations during storage. The results of the sensory evaluation were analyzed using Kruskal-Wallis non-parametric one-ay ANOVA test. The FFA and the PV of butter were determined by the conventional titration techniques. The data were statistically analyzed using t-test and LSD (least significant difference). The microbiological populations such as yeast and mould count and the coliform counts were also determined. Results showed that addition of ginger oil at 0.68%, 0.82%, 0.96% (v/v) gives improved sensory properties whereas 0.54% and 1.10% (v/v) concentrations were not acceptable. The anti-oxidative effect of ginger oil in 0.82% and 0.96% (v/v) concentration was similar to that of the positive control with artificial antioxidants and, moreover, sample with 0.68% ginger oil showed significantly lower ($p<0.05$) FFA and PV values than the positive control sample. The developed product was safe for human consumption throughout the storage period. Therefore, it can be concluded that ginger oil can be successfully introduced to the butter industry to produce herbal butter with natural antioxidants in order to improve its sensory as well as shelf-life.

Keywords: Butter, storage stability, Peroxide value, free fatty acids, Ginger oil

Introduction

Butter is one of the most popular dairy products consumed by people in the world. There are specific standards recommended for butter and according to specifications of SLSI, butter can contain a maximum of 0.3% of FFA (as oleic acid by mass) (SLSI, 1988). Now-a-days, butter manufacturers face the problem of lipid oxidation which limits the shelf-life of their products. Dairy products, such as butter and ghee that have a high lipid content and unsaturated fatty acids, tend to become rancid during storage due to the oxidation of polyunsaturated fatty acids. Oxidative rancidity of unsaturated fatty acids occurs as a result of the oxidation of C=C bonds and results in formation of hydro peroxide. Oxidation is promoted by the presence of oxygen at high T° and a_w (Ahmet, 2010). The enzymatic hydrolysis of milk fat occurs due to lypolysis causing an accumulation of FFA some of which are responsible for the rancid flavor of milk and milk products. Normally, FFA level in milk is 0.18-0.28% (Wiking, 2005). In determining storage stability of butter, peroxide value and the amount of free fatty acids in the butter need to be taken into consideration (Ahmet, 2010). Peroxide value of the butter is a measure of oxidation of fatty acids. An off flavor is perceived in butter when the peroxide value reaches 2 meq O_2/kg of fat and the maximum acceptable synthetic antioxidant level for edible fat is 10 meq O_2/kg (Izzreen, 2011). Ginger contains several powerful antioxidants and is, thus, one of the most important spices for preventing and curtailing oxidative stress. In addition to their direct antioxidant properties, several of the compounds work indirectly by enhancing the action of other antioxidants. Therefore, the objective of the present research study were to determine the effective concentration of the ginger oil that can be added to arrest oxidation of lipids in butter during storage and to determine the effect of ginger extract on peroxide value and free fatty acid content in butter.

Materials and methods

Ginger oil (*Zingiber officinale* L.) was separately added to butter in 0.54% (treatment A), 0.68% (treatment B), 0.82% (treatment C), 0.96% (treatment D), and 1.10% (treatment E) (v/v) concentrations with four replicates according to a Completely Randomized Design (CRD). The free fatty acid content and the peroxide value of the butter were determined by the conventional titration methods (AOAC, 1995) and a sensory evaluation was carried out to find out the suitable concentration of ginger that can be added to butter to improve its sensory properties. Total colony counts, yeast and mould counts and *Coliform* counts were used to determine the microbial quality of the developed herbal butter. Data were analyzed using ANOVA with SAS (ver 9.1) statistical software for Windows. Sensory data were analyzed using Kruskal-Wallis one way ANOVA test with the statistical software package STATISTIX (ver 2.0) for Windows. Significantly different means were separated using LSD. Experiments were conducted in duplicate to draw statistically valid inferences.

Results and discussion

According to results of sensory evaluation (data not shown), there were no significant differences (P>0.05) among all treatments in terms of appearance and texture of the final product. Treatments A, B and C were significantly different (P<0.05) from D and E in terms of aroma and taste. In a similar study, Ayar *et al.* (2001) also reported that the use of plant extracts can impart an acceptable odor and taste to the final product.

Table 1 Changes in Peroxide Value (PV) and free fatty acid (FFA) content of herbal butter during storage at 4 °C

	Weeks	NC	A	B	C	D	E	PC
	2	0.30	0.30^{a}	0.30^{a}	0.30^{a}	0.30^{a}	0.30^{a}	0.30^{a}
FFA	6	0.32	0.32^{ab}	0.32^{ab}	0.31^{bc}	0.31^{bc}	0.30^{c}	0.30^{c}
	10	0.36	0.36^{a}	0.35^{ab}	0.34^{bc}	0.33^{bc}	0.33^{c}	0.33^{c}
	2	1.2	0.87^{ab}	0.87^{ab}	0.62^{b}	0.58^{b}	0.58^{b}	0.56^{b}
PV	6	2.83	2.2^{ab}	2.73^{a}	1.8^{bc}	1.36^{bc}	1.1^{c}	0.93^{c}
	10	5.7	5.49^{a}	5.02^{a}	3.7^{bc}	3.9^{bc}	3.16^{bc}	2.93^{c}

PC-Positive control/commercial product with synthetic anti-oxidants, A-0.54% ginger oil added butter, B-0.68% ginger oil added butter, C-0.82% ginger oil added butter, D-0.96% ginger oil added butter, E-1.10 % ginger oil added butter, NC-Negative control without anti-oxidants. *Means with different superscripts (a, b, c) are significantly different (P<0.05) from each other*

TFFA values of butter produced in each treatment were not significantly different (P>0.05) from one another after 2 weeks of storage (Table 1). Further, positive control and treatment E did not show any significant difference (P>0.05) in FFA content and peroxide value after 6 and 10 weeks of storage. In a similar study, Lindsay (1983) showed that addition of plant derived antioxidants in high concentrations was able to protect the butter from getting rancid quickly since plant derived antioxidants can function as singlet or triplet oxygen quenchers, free radical scavengers and peroxide decomposers. Further, Gan *et al.* (2004) reported that more reactive intermediate products were produced in an electron deficient environment. Moreover, he showed the ability of plant extracted anti-oxidants to slow down the rate of the production of more reactive intermediate products such as peroxides, hydro-peroxides or free radicals in all the treatments. It could however not stop completely the production of peroxides or hydro-peroxides but could only slow down the rate of their production. Ayar *et al.* (2001) reported that addition of ginger extract increases the storage stability of butter while improving the sensory properties. The observations in the present research study are in agreement with those of previously reported studies.

Yeast and molds count of selected samples added with 0.68% 0.82% and 0.96% (v/v) ginger oil did not exceed the recommended level (70 CFU/g) during the storage period. It was observed that the growth of yeast and molds is successfully suppressed by addition of ginger oil. *Colifoms* and *E. coli* were not detected in the developed herbal butter.

Conclusions

The results of the present study show that the incorporation of natural antioxidant of ginger into butter brings significant effect (P<0.05) on the storage stability of butter especially in the 0.82% and 0.96% (v/v) concentration at storage temperature of 4 °C. Ginger oil can be successfully introduced to butter industry considering its anti-oxidative and anti-fungal properties to increase the self-life instead of use of artificial anti-oxidative and anti-fungal compounds. Free fatty acids content and the peroxide value of the butter show some degree of concentration dependency as higher extract concentrations gave lower peroxide and free fatty acid values during entire storage period of time.

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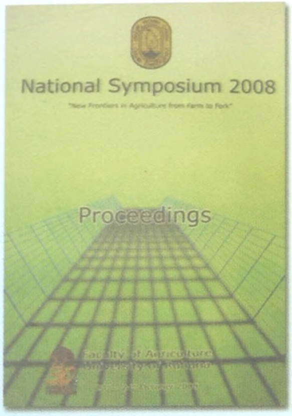

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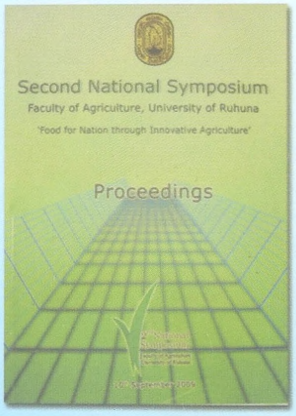

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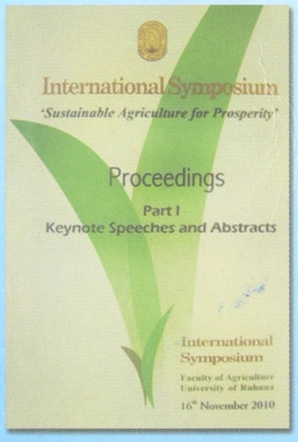

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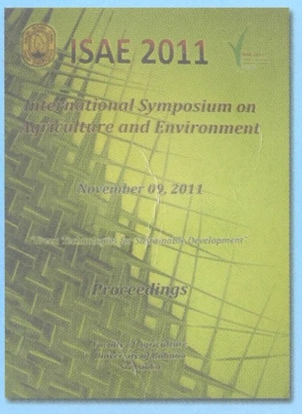

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